PATENT SPECIFICATION

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743,972

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COMPLETE SPECIFICATION

Improvements in Connectors for Pressure Fluid Distribution Systems

We, ELLIOTT BROTHERS (LONDON) LIMITED, a Company registered under the laws of Great Britain, of Century Works, Lewisham, London, S.E.13, England, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to pressure fluid distribution systems and is concerned with a connector for coupling the pressure fluid conduits of a number of related pieces of apparatus to one another and/or to a source or sources of fluid supply. The pieces of apparatus referred to may, for example, comprise pressure regulating units, filters, pilot valves, control instruments and other devices in which the pressure of the fluid is utilised with or without there being any consumption of the fluid.

It is the main object of the present invention to provide an improved connector such that the pieces of apparatus shall be capable of ready connection thereto and disconnection therefrom without the necessity for making and breaking pipe connections and substantially in the same manner and with the same ease as electrical appliances may be plugged into circuits on an electrical distribution board.

A further object of the invention is to make it possible to produce relatively involved passages for the flow of pressure fluid through the connector without the necessity either for bending complex pipe forms or for soldering, brazing or like operations.

Accordingly, the invention consists of a connector having fluid passages capable of being selectively coupled to the pressure fluid conduits of a number of related pieces of apparatus and to a source or sources of fluid supply, the passages being formed within the thickness of a panel member and leading to outlets and inlets formed from one or more faces thereof and the arrangement being such that pieces of apparatus formed with inlets, outlets or both inlets and outlets are capable of being detachably coupled in a leakproof manner with appropriate outlets, inlets or both outlets and inlets on the panel member.

Preferably each outlet of the panel member through which, if unoccupied, pressure fluid would escape is fitted with a non-return valve which is normally urged to the closed position by the pressure of the fluid, means being provided to unseat the valve and hold it in the open position on coupling one of said pieces of apparatus in co-operation therewith.

Some of the operative connections may be established between the pieces of apparatus and the panel member by the engagement of tubular spigot members with socket formations which are fitted with radially compressible, elastic sealing means adapted to produce a fluid-tight seal when the spigot member is pressed home into the socket formation. The tubular spigot members may be mounted on the panel member or on the piece of apparatus, the socket formations being arranged on the piece of apparatus or on the panel, as the case may be. The means adapted to unseat the non-return valve may comprise a plug having a valve-engaging extension and formed with ports for establishing communication with a passage in the plug, the arrangement being such that when the plug is pushed home into the appropriate panel outlet, the extension thereon will engage and displace the non-return valve and the ports in the plug will be located within the passage in the panel member into which pressure fluid is released by the opening of the valve, this fluid passing into the passage in the plug and thence to the piece of apparatus concerned. In one arrangement, the plug may be fixed in the inlet on the piece of apparatus and in another, the plug may constitute a permanently mounted feature of the panel member, it being slidably disposed within a tubular spigot

[*Price 3s. 0d.*] Price 4s 6d

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1 SHEET

FIG. 1.

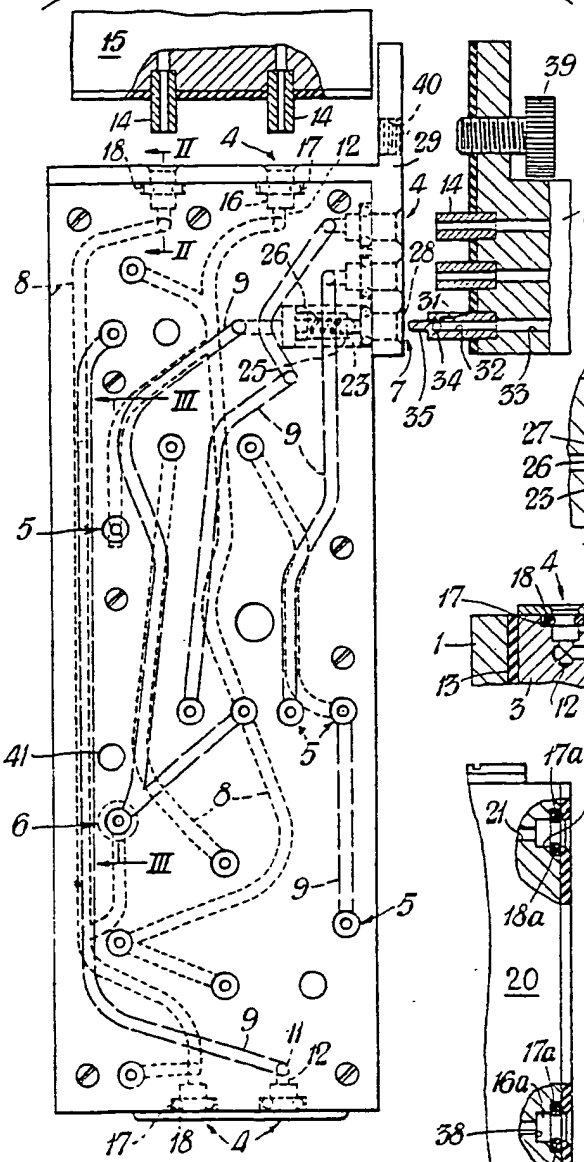

FIG. 4.

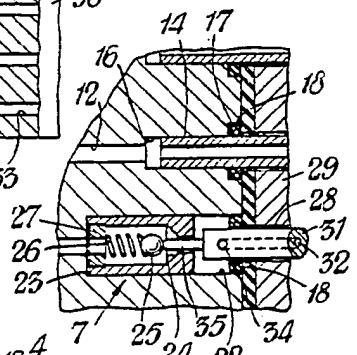

FIG. 2.

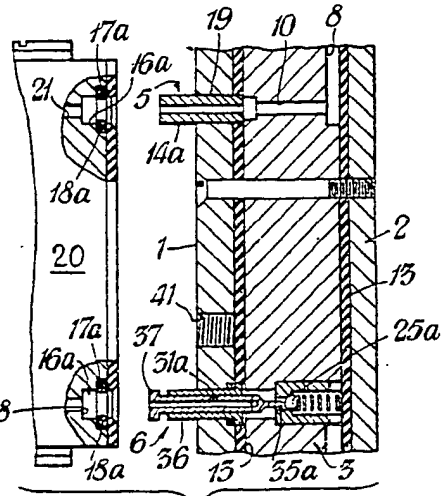

FIG. 3.

secured in the latter so that its outer end is adapted to be engaged and displaced by the base of a socket formation in the piece of apparatus concerned when the spigot enters the formation to form a fluid-tight seal therewith. This displacement of the plug causes the extension thereon to unseat the valve while, at the same time, the ports in the plug are brought inwards of the edge of a wall of the spigot member which otherwise obturates those ports, the plug normally being held in an outer position by the pressure exerted by the non-return valve.

In a preferred construction the panel member is formed in three superposed portions, the central portion being formed with grooves in the upper and lower faces to constitute passages for the flow of the pressure fluid, these passages being interconnected, if desired, by bores formed through the body of the central portion. Top and bottom portions are adapted to be secured upon the upper and lower faces of the central portion, with the interposition of sealing means adapted to prevent leakage from one passage to another or to the external atmosphere, and the top portion is formed with outlet apertures to register with the respective passages. In some cases additional outlets may open into one of the edge faces of the panel and main supply connections may be formed in another edge face of the panel to lead into appropriate pressure fluid passages therein.

It will be appreciated that where the pressures to be encountered are relatively high, the pieces of apparatus may also be provided with positive retaining means adapted to engage the panel when the piece of apparatus is coupled thereto.

The invention will be clearly understood from the following more detailed description of one example of the way in which it may be carried into effect, reference being made to the accompanying drawing in which:—

Fig. 1 is a front elevation of a panel member embodying the invention showing partly sectioned parts of associated pieces of apparatus being approached thereto.

Fig. 2 is a fragmentary section taken on the line II—II of Fig. 1.

Fig. 3 is a fragmentary section of the panel member taken on the line III—III of Fig. 1 showing a partly sectioned part of a further associated piece of apparatus being approached thereto, and

Fig. 4 is a fragmentary section to a larger scale showing in the engaged condition two of the connections of one of the pieces of apparatus indicated in Fig. 1.

This example is concerned with a connector comprising an air distribution panel for use in connection with pneumatic controlling gear comprising a number of separate pieces of apparatus which, in use, must be interconnected in a predetermined manner. Examples of such pieces of apparatus are a pneumatic controller unit, a unit adapted to convert an electric or other input signal into a pneumatic output pressure or pressures, a pilot valve unit, an air filter unit and a pressure regulator unit.

In order that several such units may conveniently be connected in the required manner and also be readily disconnected for purposes such as those of inspection, cleaning or adjustment without the necessity for making, breaking and remaking pipe joints, the units are provided with means whereby they may be plugged into a panel in a manner analogous to that in which electrical units may be plugged into a distribution board.

The panel is composed of three main elements consisting of top and bottom plates 1 and 2 respectively and an intermediate block 3 (see Figs. 2 and 3). The latter, which may be a casting in aluminium, is formed on its upper and lower faces with grooves or channels adapted to constitute passages for the flow of compressed air from one connecting point to another, certain of such connecting points being marked 4, 5, 6 or 7 in Fig. 1. Those passages formed in the lower face of the block 3 are indicated in broken lines composed of short dashes and are marked 8 while those passages formed in the upper face of the block are indicated in broken lines composed of long dashes and are marked 9. These passages follow any appropriate path, which may be rectilinear, curvilinear or sinuous, and are distributed between the upper and lower faces of the block in the most convenient manner for producing the desired connections, bores 10 (such as shown in Fig. 3) being formed through the thickness of the block to interconnect passages on the upper and lower faces thereof where necessary. In some cases, as at 11 in Fig. 2, the bore may extend part-way through the block 3 in order to open into a further bore 12 formed parallel with the upper and lower faces and opening into one of the edges of the block.

At each point at which a connection is required to be made to the passages 8 and 9 there is provided an outlet or inlet such as 4, 5, 6 or 7 which may be located at the end of a passage or at a point along the length of a passage. Most of the outlets are apertures formed in the upper plate 1 of the complete panel although some, as has been indicated at 4, are bores opening into the edges of the latter, for example to constitute main fluid supply connections.

It will be understood that the three main composents of the panel are secured firmly together with the interposition of gaskets 13 of rubber, or a similar elastic composition, which will prevent cross-leakages of pressure fluid from one passage 8 or 9 to another.

The outlets or inlets 4, 5, 6 or 7 may be of different characters depending upon the

nature of the co-operating formations on the respective units which are to be plugged into the panel. Some examples of suitable constructions of outlets and inlets with the appropriate formations on the units will now be described.

A simple form of inlet or outlet (shown at 4 in Fig. 1) for co-operating with a plain tubular projection 14 on the unit 15 comprises a cylindrical bore 16 opening at its inner end by way of bores 12 and 11 to one of the passages 8 or 9 in the block and having its wall formed towards the outer end with an annular recess 17 within which is located a packing ring 18 of an elastic composition. The diameter of the bore 16 is slightly larger than the external diameter of the tubular projection 14 on the unit 15 and the depth of the groove or recess 17 and the radial dimension of the packing ring 18 are such that the inner portion of this ring will normally project substantially into the passage through the bore 16. It will be understood that when the unit 15 is placed in position, the tubular projection 14 enters the bore 16 and in so doing compresses the packing ring 18 radially in order to produce a fluid-tight joint.

In another form of inlet or outlet shown at 5 (Figs. 1 and 3) the relative dispositions of the parts just referred to are reversed, the tubular projection 14*a* being secured in an aperture 19 in the front plate 1 of the panel and the bore 16*a* being formed in the unit 20 with its inner end in communication with the appropriate passage 21 in the latter. A recess 17*a* and packing ring 18*a* are provided to correspond to the recess 17 and ring 18 of an inlet or outlet 4.

A form of outlet, such as that shown at 7 in Figs. 1 and 4, which is particularly appropriate for use where the passage 9 leading thereto is one which normally contains fluid under pressure, involves the provision in the block portion 3 of the panel of a non-return valve. This valve is housed within an appropriate bore 22 formed in the block and consists of a sleeve 23 slidably fitted within the bore 22 and having a seating 24 at its outer end towards which a ball 25 is urged by a spring 26 housed within the sleeve 23. The spring 26 bears at one end on the ball and at the other upon an annulus 27 secured in the inner end of the sleeve 23. The disposition of the valve is such that the action of the fluid pressure tends to hold the ball 25 upon its seat. A bore 28 is formed through a face plate 29 secured to the edge of the block 3 to give access to the ball 25. A radially compressible packing ring 18 of the character already referred to is accommodated in the bore 22 between the sleeve 23 and the underside of the face plate 29. The co-operating formation on the unit 30 may then comprise a plug 31 formed from its inner end with an axial bore 32 which terminates short of the outer end of the plug. This bore will be in communication with the appropriate passage 33 in the unit 30 at its inner end. One or more transverse bores 34 are formed through the wall of the plug 31 to open into the outer end of the axial bore 32 and the free extremity of the plug is formed with a reduced axial extension constituting a displacing pin 35. The dimensions of the parts are such that when the unit 30 is placed in position, the plug 31 will have entered the bore 22 compressing the packing ring 18 radially, and the transverse bore or bores 34 will be located inwardly of the ring 18 while the pin 35 on the plug will engage the ball 25 and hold it from its seat. The sleeve 23 slides inwardly of the bore 22 and the ring 18 is held in its original position at the outer end of the bore 22 by the action of the pressure fluid.

In an alternative arrangement shown in Fig. 3, a plug 31*a* of the construction just described is displaceably mounted in the outlet 6 on the top plate 1 with its displacing pin 35*a* normally engaged with the ball 25*a*. The plug 31*a* is a close sliding fit in a tubular projecting outlet 36 secured in the top plate 1 and has a flange 37 at its outer end adapted to bear on the outer end of the tubular projection 36 when the plug 31*a* is forced inwards sufficiently to displace the ball 25*a* from its seat. The external diameter of this flange 37 is substantially the same as that of the tubular projection 36. In this arrangement, the co-operating formation on the unit 20 is an inlet of the same character as the inlets or outlets 4 already described it having a bore 16*a* formed with an annular recess 17*a* to receive a radially compressible packing ring 18*a*. When the unit 20 is placed in position, the outer end of the plug 31*a* together with the tubular projection 36 enter the bore 16*a*, the wall of the projection 36 compressing the packing ring 18*a* and the end of the plug 31*a* eventually being displaced by contact with the bottom end 38 of the bore 16*a* to cause the ball valve 25*a* to be displaced from its seat.

It is to be understood that each unit may be fitted with one or more outlet or inlet-engaging formations which, where there are more than one, may be all the same or all different, or may comprise a mixture of the different types already described.

In the case of some units the engagement thereof with the appropriate outlets or inlets on the panel will be sufficient to hold them in position but in other cases it is preferred to provide positive means for holding the unit in position on the panel. These means are of a character making it a simple matter to disconnect them when necessary, for example as illustrated in Fig. 1, a securing screw 39 may be mounted on the unit 30 to engage a screw-threaded aperture 40 formed in the face plate 29. The unit 20 may similarly be

held positively to the panel by a screw (not shown) adapted to engage the screw-threaded aperture 41 formed in the top plate 1.

By the aid of the apparatus described it becomes a simple matter to produce complex pneumatic couplings without the necessity for producing complicated pipe bends. Moreover, the several units may be connected and when necessary disconnected, by a simple operation not involving the making or breaking of pipe joints and, in those cases where the non-return valves are provided, the appropriate units may be removed while the pressure fluid supply is still established without causing loss of the pressure fluid and, in some instances, without interrupting the functioning of the pressure fluid distribution system.

What we claim is:—

1. A connector having fluid passages capable of being selectively coupled to the pressure fluid conduits of a number of related pieces of apparatus and to a source or sources of fluid supply, the passages being formed within the thickness of a panel member and leading to outlets and inlets formed from one or more faces thereof and the arrangement being such that pieces of apparatus formed with inlets, outlets or both inlets and outlets are capable of being detachably coupled in a leakproof manner with appropriate outlets, inlets or both outlets and inlets on the panel member.

2. A connector according to claim 1 in which each outlet of the panel member through which, if unoccupied, pressure fluid would escape is fitted with a non-return valve which is normally urged to the closed position by the pressure of the fluid, means being provided to unseat the valve and hold it in the open position on coupling one of said pieces of apparatus in co-operation therewith.

3. A connector according to claim 2, wherein the operative connection between a piece of apparatus and the panel member is established by the engagement of a tubular spigot member with a socket formation which is fitted with a radially compressible, elastic sealing means adapted to produce a fluid-tight seal when the spigot member is pressed home into the socket formation.

4. A connector according to claim 2 or 3, wherein the means adapted to unseat the non-return valve comprises a plug having a valve-engaging extension and formed with ports for establishing communication with a passage in the plug, the arrangement being such that when the plug is pushed home into the appropriate panel outlet, the extension thereon will engage and displace the non-return valve and the ports in the plug will be located within the passage in the panel member so that the pressure fluid released by the opening of the valve may pass through the passage in the plug.

5. A connector according to claim 4, wherein the plug is mounted on a piece of apparatus.

6. A connector according to claim 4, wherein the plug is mounted on the panel member and is slidably disposed within a tubular spigot secured in the latter so that the outer end of the plug is adapted to be engaged and displaced by the base of a socket formation in the piece of apparatus concerned when the spigot enters the socket formation to form a fluid-tight seal therewith.

7. A connector according to any one of the preceding claims, wherein the panel member is formed in three superposed portions, the central portion being formed with grooves in its upper and lower faces to constitute said passages for the flow of the pressure fluid.

8. A connector according to claim 7, wherein the passages are interconnected by bores formed through the body of the central portion.

9. A connector according to claim 7 or 8, wherein the top and bottom portions are adapted to be secured upon the upper and lower faces of the central portion with the interposition of sealing means adapted to prevent leakage of the pressure fluid from one passage to another or to the external atmosphere.

10. A connector according to any one of claims 7, 8 or 9, wherein the top portion of the panel member is formed with apertures adapted to register with the respective passages.

11. A connector according to any one of claims 7 to 10, wherein main supply connections are formed in an edge face of the panel member to lead into appropriate fluid passages therein.

12. A connector according to any one of the preceding claims, wherein the pieces of apparatus are provided with positive retaining means capable of being engaged with the panel member when the piece of apparatus is plugged into position.

13. A connector having fluid passages capable of being selectively coupled to the pressure fluid conduits of a number of related pieces of apparatus constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawing.

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PROVISIONAL SPECIFICATION

Improvements in Connectors for Pressure Fluid Distribution Systems

We, ELLIOTT BROTHERS (LONDON) LIMITED, a Company registered under the laws of Great Britain, of Century Works, Lewisham, London, S.E.13, do hereby declare this invention to be described in the following statement:—

This invention relates to pressure fluid distribution systems and is concerned more particularly with those systems comprising a number of related pieces of apparatus each designated to utilise or control the flow of the pressure fluid and interconnected in a predetermined sequence by passages for conducting the pressure fluid. The pieces of apparatus referred to may, for example, comprise pressure regulating units, filters, pilot valves, control instruments and other devices in which the pressure of the fluid is utilised with or without there being any consumption of the fluid.

It is the main object of the present invention to provide an improved system of this character in which the pieces of apparatus shall be capable of ready connection into and disconnection from the remainder of the system without the necessity for making and breaking pipe connections and substantially in the same manner and with the same ease as electrical appliances may be plugged into circuits on an electrical distribution board.

A further object of the invention is to make it possible to produce in the system relatively involved circuit arrangements for the passage of the pressure fluid without the necessity either for bending complex pipe forms or for soldering, brazing or like operations.

Accordingly, the invention consists in a system of the character referred to wherein the passages constituting the circuits for the flow of the pressure fluid are formed in a panel member and lead to outlets or inlets formed from one or more faces of the member, each outlet through which, if unoccupied, pressure fluid would escape from the system being fitted with a non-return valve which is normally urged to the closed position by the pressure of the fluid, and wherein the pieces of apparatus are formed with inlet, outlet or both inlet and outlet connections capable of co-operating in a leak-proof manner with appropriate outlets on the panel member, means being so provided, either on the piece of apparatus or on the panel, in association with each of those outlets fitted with a non-return valve that the inter-engagement of the corresponding connection and the outlet will cause the valve to be unseated and held in the open position.

Some of the operative connections may be established between the pieces of apparatus and the panel member by the engagement of tubular spigot members with socket formations which are fitted with radially compressible, elastic sealing means adapted to produce a fluid-tight seal when the spigot member is pressed home into the socket formation. The tubular spigot members may be mounted on the panel member or on the piece of apparatus, the socket formations being arranged on the piece of apparatus or on the panel, as the case may be. The means adapted to unseat the non-return valve may comprise a plug having a valve-engaging extension and formed with ports for establishing communication with a passage in the plug, the arrangement being such that when the plug is pushed home into the appropriate panel outlet, the extension thereon will engage and displace the non-return valve and the ports in the plug will be located within the passage in the panel member into which pressure fluid is released by the opening of the valve, this fluid passing into the passage in the plug and thence to the piece of apparatus concerned. In one arrangement, the plug may be fixed in the inlet connection on the piece of apparatus and in another, the plug may constitute a permanently mounted feature of the panel member, it being slidably disposed within a tubular spigot secured in the latter so that its outer end is adapted to be engaged and displaced by the base of a socket formation in the piece of apparatus concerned when the spigot enters the formation to form a fluid-tight seal therewith. This displacement of the plug causes the extension thereon to unseat the valve while, at the same time, the ports in the plug are brought inwards of the edge of a wall of the spigot member which otherwise obturates these ports, the plug normally being held in an outer position by the pressure exerted by the non-return valve.

In a preferred construction the panel member is formed in three superposed portions, the central portion being formed with grooves in its upper and lower faces to constitute channels for the flow of the pressure fluid and these channels being interconnected, if desired, by bores or passages formed through the body of the portion. The upper and lower portions are adapted to be secured upon the top and bottom faces of the central

portion, with the interposition of sealing means adapted to prevent leakage from one channel to another or to the external atmosphere, and the upper portion is formed with outlet apertures to register with the respective channels. In some cases additional outlets may open into one of the edge faces of the panel and main supply connections may be formed in another edge face of the panel to lead into appropriate pressure fluid channels therein.

It will be appreciated that where the pressures to be encountered are relatively high, the pieces of apparatus may also be provided with positive retaining means adapted to engage the panel when the piece of apparatus is plugged into position.

The invention will be clearly understood from the following more detailed description of one example of the way in which it may be carried into effect.

This example is concerned with an air distribution panel for use in connection with pneumatic controlling gear comprising a number of separate pieces of apparatus which, in use, must be inter-connected in a predetermined manner. Examples of such pieces of apparatus are a pneumatic controller unit, a unit adapted to convert an electric or other input signal into a pneumatic output pressure or pressures, a pilot valve unit, an air filter unit and a pressure regulator unit.

In order that these several units may conveniently be connected in the required manner and also be readily disconnected for purposes such as those of inspection, cleaning or adjustment without the necessity for making, breaking and remaking pipe joints, the several units are provided with means whereby they may be plugged into a distribution panel in a manner analogous to that in which electrical units may be plugged into a distribution board.

The panel is composed of three main elements consisting of top and bottom plates and an intermediate block. The latter, which may be a casting in aluminium, is formed on its upper and lower surfaces with grooves or channels adapted to constitute passages for the flow of compressed air from one connecting point to another. These passages follow any appropriate path, which may be rectilinear, curvilinear or sinuous, and are distributed between the upper and lower surfaces of the block in the most convenient manner for producing the desired circuit connections, bores or ports being formed through the thickness of the block to interconnect passages on the top and bottom faces thereof where necessary. In some cases, the bore may extend part-way through the block in order to open into a further bore formed parallel with the top and bottom surfaces and opening into one of the edges of the block.

At each point at which a connection is required to be made to the passages there is provided an outlet which may be located at the end of a passage or at a point along the length of a passage. Most of these outlets are apertures formed in the upper plate of the complete panel although some, as has been indicated, are bores opening into the edges of the latter.

It will be understood that the three main components of the panel are secured firmly together with the interposition of gaskets of rubber, or a similar elastic composition, which will prevent cross-leakages of pressure fluid from one passage to another.

The outlets may be of different characters depending upon the nature of the co-operating formations on the respective units which are to be plugged into the panel. Some examples of suitable constructions of outlets with the appropriate formations on the units will now be described.

A simple form of outlet for co-operating with a plain tubular projection on the unit comprises a cylindrical bore opening at its inner end to one of the passages in the block and having its wall formed towards the outer end with an annular recess within which is located a packing ring of an elastic composition. The diameter of the bore is slightly larger than the external diameter of the tubular projection on the unit and the depth of the groove and the radial dimension of the packing ring are such that the inner portion of this ring will normally project substantially into the passage through the bore. It will be understood that when the unit is placed in position, the tubular projection enters the bore and in so doing compresses the packing ring radially in order to produce a fluid-tight joint.

In another form of outlet the relative dispositions of the parts just referred to are reversed, the tubular projection being secured in an aperture in the front plate of the panel and the bore being formed in the unit with its inner end in communication with the appropriate passage in the latter.

A form of outlet which is particularly appropriate for use where the passage leading thereto is one which normally contains fluid under pressure, involves the provision in the block portion of the panel of a non-return valve. This valve is housed within an appropriate bore formed in the block and preferably consists of a ball urged towards a seat by a spring, the disposition of the valve being such that the action of the fluid pressure tends to hold the ball upon its seat. A bore is formed through the block from the front face thereof to give access to the ball and a registering aperture is formed through the top plate. In one arrangement of this character the aperture in the top plate is formed with an annular recess in its wall to accommodate a radially compressible packing ring of the character already referred to. The co-operating element on the unit may then comprise a plug formed

from its inner end with an axial bore which terminates short of the outer end of the plug. This bore will be in communication with the appropriate passage in the unit at its inner end. One or more transverse bores are formed through the wall of the plug to open into the outer end of the axial bore and the free extremity of the plug is formed with a reduced axial extension constituting a displacing pin. The dimensions of the parts are such that when the unit is placed in position, the plug will enter the appropriate aperture on the panel, compressing the packing ring radially, and the transverse bore or bores will be located inwardly of the ring while the pin on the plug will engage the ball and hold it from its seat.

In an alternative arrangement, a plug of the construction just described is displaceably mounted in the outlet on the top plate with its displacing pin normally engaged with the ball. The plug is a close sliding fit in a tubular outlet secured in the top plate and has a flange at its outer end adapted to bear on the outer end of the tubular projection when the plug is forced inwards sufficiently to displace the ball from its seat. The external diameter of this flange is substantially the same as that of the tubular projection. In this arrangement, the co-operating formation on the unit is a bore formed with an annular recess to receive a radially compressible packing ring. When the unit is placed in position, the outer end of the plug together with the tubular projection enter the bore, the wall of the projection compressing the packing ring and the end of the plug eventually being displaced by contact with the bottom end of the bore to cause the ball valve to be displaced from its seat.

It is to be understood that each unit may be fitted with one or more outlet-engaging formations which, where there are more than one, may be all the same or all different, or may comprise a mixture of the different types already described.

In the case of some units the engagement thereof with the appropriate outlets on the panel will be sufficient to hold them in position but in other cases it is preferred to provide positive means for holding the unit in position on the panel. These means are of a character making it a simple matter to disconnect them when necessary, for example, a securing screw may be mounted on the unit to engage a screw-threaded aperture formed in the appropriate surface on the panel.

By the aid of the apparatus described it becomes a simple matter to produce complex pneumatic circuits without the necessity for producing complicated pipe bends. Moreover, the several units may be connected into the circuits, and when necessary disconnected, by a simple operation not involving the making or breaking of pipe joints and, in those cases where the non-return valves are provided, the appropriate units may be removed while the pressure fluid supply is still established without causing loss of the pressure fluid and, in some instances, without interrupting the functioning of the system.

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